MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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A report on Annapolis' present and potential Urban Tree Canopy

Prepared for:

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City of Annapolis

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June 7, 2006

Summary

On January 12, 2005, the Maryland Department of Natural Resources (MD DNR) invited the City of Annapolis to participate in the Urban Tree Canopy (UTC) goal setting process in accordance with the Chesapeake Bay Program's Riparian Forest Buffer Directive No. 03-01. Mayor Ellen Moyer accepted the offer shortly thereafter.

During the following fall and winter city staff, MD DNR, and representatives from US Forest Service and the University of Vermont Spatial Analysis Lab developed analytical methods for the UTC analysis, and established timelines for UTC goal setting completion.

Researchers from the US Forest Service and the University of Vermont Spatial Analysis Lab coordinated with MD DNR and performed the agreed upon analyses. Using various GIS data, including high-resolution remote sensing data interpreted for trees and other vegetation and parcel information from the Maryland Department of Planning, the team was able to quantify existing UTC and possible UTC by geographical boundaries and parcel land use type. Possible UTC was classified into enhancement scenarios based on the 25th, 50th, and 75th percentiles. Results were compared with median UTC for Maryland communities as well as with existing and target UTC for various jurisdictions that have set UTC goals.

While it is easy to think of UTC enhancement in terms of planting trees, UTC enhancement requires a combination of tree protection, tree maintenance, and tree planting to be fully realized and efficiently implemented. The impacts of setting a UTC goal will likely include PROW and public Exempt Commercial lands. On private lands, a combination of education and outreach, landowner incentives, and refocusing of regulatory mechanisms (Critical Area Law, Forest Conservation Act, Landscape Ordinance, etc.) to specifically achieve the objectives of the UTC goal will likely be required. As trees and tree crowns take time to grow, UTC planning has a temporal as well as a quantitative element. Twenty to thirty years' time will be needed to achieve a significant increase in UTC.

The basic premise of UTC enhancement is water quality improvement related to the Chesapeake Bay. In a study of all (245) small watersheds in Montgomery County, MD, Goetz et al. (2003) found overall of tree cover of 44.6% to be associated with stream health ratings of "good", with increases in overall UTC associated with improvements in stream health ratings and decreases in overall UTC associated with declines in stream health ratings.

We recommend that Annapolis adopt a 50% UTC goal to be attained by 2036, with remote sensing assessment of progress in attaining the UTC goal at 10-year intervals. This goal corresponds to the 25th percentile enhancement scenario and slightly exceeds the target established by Goetz (2003). Such a goal would make Annapolis a leader in UTC among US cities.

We recommend that the US Forest Service Northeast Research Station, MD DNR Forest Service, and the Chesapeake Bay Program work with the City to:

1. Develop an implementation plan to realize the UTC goal;
2. Issue an updated report containing the newly annexed areas and reflecting the updated ward boundaries within six months of the availability of digital shapefiles for the new ward boundaries; and,
3. Provide ongoing technical assistance on implementation and monitoring UTC goal progress.

*To assist in use of this document, terms that may require explanation are introduced in the body in **bold italics** and defined in the Glossary section. At a hyperlink to a Figure or Table, click on the link and you will go to that Figure or Table.*

Assignment

The assignment as identified by the client (City of Annapolis) was to help Annapolis to be a pilot community for the Urban Tree Canopy program.

Background

The Chesapeake Bay Program's Riparian Forest Buffer Directive No. 03-01 (Chesapeake Executive Council) was signed in December 2003. This expanded riparian buffer directive "...recognizes that urban tree canopy cover offers stormwater control and water quality benefits for municipalities in the Chesapeake Bay watershed and can extend many riparian forest buffer functions to urban settings" and commits to, among others, the following goals:

- By 2010, work with at least 5 local jurisdictions and communities in each state to complete an assessment of urban forests, adopt a local goal to increase urban tree canopy cover and encourage measures to attain the established goals in order to enhance and extend forest buffer functions in urban areas; and,
- Encourage increases in the amount of tree canopy in all urban and suburban areas by promoting the adoption of tree canopy goals as a tool for communities in watershed planning.

On January 12, 2005, the Maryland Department of Natural Resources (MD DNR) sent a written invitation to Mayor Moyer. The letter invited Annapolis to be one of the five (5) communities referred to in the directive noted, and committed to provision of technical assistance in the event of acceptance.

On January 28, 2005, Mayor Moyer responded by letter, committing to participation.

On November 4, 2005, the initial goal-setting meeting was held at City Hall. Participants included Annapolis and MD DNR staff. The group reviewed data and methods, agreed upon certain analyses and set a date to review results and recommend a goal. The timeline called for:

1) An updating of data, methods, analyses, and subsequent report of results by spring 2006;
2) The development of a goal recommendation in early 2006, and
3) A report for the City to review in order to make an announcement on a UTC Goal.

On May 26, 2006, the final goal setting meeting was held at City Hall. Participants reviewed and discussed data and analyses noted in the remainder of this report.

Methods

Existing And Possible Canopy Cover

Existing UTC was extracted from the MD DNR ***Strategic Urban Forests Assessment*** (SUFA) land cover layer that was created from high-resolution leaf-on ***IKONOS*** satellite imagery in 2004 (Irani and Galvin 2003). Using a geographic information system (GIS) the SUFA layer was overlaid on a composite layer consisting of street and parcel boundaries. Parcel land use type was determined by linking the Parcel data with the MD Property View® dataset. PROW was used to describe non-parcel areas consisting of both roads and the adjacent land. Due to provision of the building and road layers, we were also able to calculate the amount of UTC overhanging improvements.

To estimate ***possible UTC***, building footprints and water features were added to the above composite layer containing UTC, streets, and parcels. Possible UTC was defined as any piece of land in the city not occupied by a building, existing UTC, a street, or water. Thus, those areas that are deemed possible largely consist of grass and non-road/non-building paved surfaces.

By combing the building footprint layer and the roads layer with the SUFA (UTC) layer, we were also able to calculate existing UTC overhang (UTC over improvements).

Scenarios

Possible UTC was classified into scenarios based on 25th, 50th, and 75th percentiles. Results were compared with median UTC for Maryland communities as well as with existing and target UTC for: Portland, OR (Poracsky and Lackner 2004); Vancouver, WA (Kaler and Ray 2005); Montgomery County, MD (Montgomery County 2000); Roanoke, VA (Urban Forestry Task Force and Roanoke Department of Recreation and Parks 2003); Fairfax County, VA (Funders' Network for Smart Growth and Livable Communities 2005), and, Baltimore, MD (Galvin et al. 2006a).

Results

Land use

Land use types in acres and as a percentage of the total City land area are summarized in Table 1.

Land cover

Land cover as a percentage of the total City land area is depicted in Figure 1.

Existing UTC

Existing UTC by land type in acres and as a percentage of the total City land area is summarized in Table 2. Currently, UTC covers 1,737 acres or 41% of the City. Most UTC occurs on Parcel lands (37%) in contrast to PROW (4%). The three land use types with the most existing UTC are Residential (23%), Exempt-Commercial (5%), and PROW (4%).

Possible UTC

Possible UTC by land type in acres and as a percentage of the total City land area is summarized in Table 3. The five land use types with the largest possibility for increasing canopy cover are Residential (15%), Exempt Commercial (8%), Commercial (7%), Apartments (3%), and Unknown (3%). Of these five land use types, Residential and Exempt-Commercial already have the highest levels of existing canopy cover.

Discussion

This analysis was performed based on data acquired prior to the recent annexation (March 2006) of three parcels. We have also been advised that, based on the noted annexations, ward boundaries will be redrawn in the near future and will differ from what is presented here.

The majority of land area in the City is parcel land (Figure 2). These lands contain the majority of existing UTC as well as the majority of possible UTC. The MD Property View®

dataset does not categorize land as public or private. Public lands are primarily found in the created PROW non-parcel class and in a percentage of the Exempt Commercial (EC) class. The EC class consists mostly of properties owned by the City, state and federal government, nonprofit or charitable organizations (museums, colleges), and private institutions (churches, hospitals). During the implementation phase, the public lands can be extracted from the EC class in order to identify public v. private lands, as they will likely require different approaches for UTC enhancement. The greatest opportunities for UTC enhancement exist on private Residential, Exempt Commercial, and Commercial lands, on public Exempt Commercial and possibly on PROW lands, followed by private Apartments and Unknown lands (Figure 3). Though opportunity exists on the remaining five (5) classes of land types, they each represent no more than 1% of the total possible UTC.

Existing UTC (1,737 acres) covers an area approximately the size of all Residential lands in the City (1,805 acres). The maximum possible UTC is 3,318 acres or 78% of City land area, a 91% increase. However, the probability and/or preferability of such an increase is unknown. As a public initiative on public lands only, modest canopy goal increases are achievable through PROW plantings alone. More significant increases would involve other land use types and owners as policy makers, planners, and managers considered the probability and preferability of different options.

While we may not think of trees in cities as a typical "forest," these trees provide valued services to our daily lives. These benefits include: reducing the urban heat island effect, improving water quality, saving energy, lowering city temperatures, reducing air pollution, increasing neighborhood desirability and quality of life, enhancing property values, providing wildlife habitat, facilitating social and educational opportunities, and providing aesthetic benefits. Scientists now have the ability to qualify and quantify the benefits of UTC. An increase in UTC brings an associated increase in the UTC benefits listed above (Galvin et al. 2006b).

The basic premise of this UTC enhancement effort is water quality improvement related to the Chesapeake Bay. In a study of all (245) small watersheds in Montgomery County, MD, Goetz et al. (2003) found overall of tree cover of 44.6% to be associated with stream health ratings of "good", with increases in overall UTC associated with improvements in stream health ratings and decreases in overall UTC associated with declines in stream health ratings. Realizing that the maximum "possible" UTC identified (78%) is not possible for practical purposes, we sought then to identify the maximum probable/preferable UTC in order to attain the desired water quality benefits established by Goetz (2003).

Three possible UTC scenarios were developed for Annapolis, representing low, medium, and high UTC enhancement:

1. Low: 50% UTC (Current UTC + 25% of possible UTC; Table 4)
2. Medium: 59% UTC (Current UTC + 50% of possible UTC; Table 5)
3. High: 68% UTC (Current UTC + 75% of possible UTC; Table 6).

A comparison of existing and potential UTC under scenarios 1, 2, and 3 to median UTC for Maryland communities and existing and planned UTC in four other jurisdictions that have set UTC goals is found in Figure 4.

As trees and tree crowns take time to grow, UTC planning has a temporal as well as a quantitative element. Twenty to thirty years' time will be needed to achieve a significant increase in UTC.

While it is easy to think of UTC enhancement in terms of planting trees, it is critical that UTC enhancements include a combination of tree protection, tree maintenance, and tree planting

in order to be fully realized and efficiently implemented. Luley and Bond (2002) offered the following conceptual analysis for increasing UTC: $C_T = C_B + C_N + C_G - C_M$

Where:

C_T = total UTC in the modeling domain over time (realization of UTC goal);

C_B = the existing UTC;

C_N = UTC increase from new trees (planting);

C_G = the growth of existing UTC (protection and maintenance); and,

C_M = UTC mortality or loss due to natural and man-induced causes.

UTC enhancement can be most efficiently realized by maximizing protection and maintenance in combination with new plantings. A 1999 study by the US Forest Service Northeastern Research Station found that over 65% of the trees in Baltimore were less than 15.2 cm (approximately 6") ***d.b.h***., and approximately 75% were less than or equal to 22.9 cm (approximately 9") d.b.h. If these trees are managed so that their anticipated mature crown projections are realized, significant UTC enhancement will occur in concert with planting efforts.

The impacts of setting a UTC goal will likely include focusing or reallocating public agency resources (funds, staff, etc.) to enhance UTC on Urparian and public Exempt Commercial lands. On private lands, a combination of education and outreach, landowner incentives, and refocusing of regulatory mechanisms (Critical Area Law, Forest Conservation Act, Landscape Ordinance, etc.) to specifically achieve the objectives of the UTC goal will likely be required.

Recommendations

We recommend that Annapolis adopt a 50% UTC goal to be attained by 2036, with remote sensing assessment of progress in attaining the UTC goal at 10-year intervals. This goal corresponds to the 25th percentile enhancement scenario and slightly exceeds the target established by Goetz (2003).

We recommend that the US Forest Service Northeast Research Station, MD DNR Forest Service, and the Chesapeake Bay Program work with the City to:

1. Develop an implementation plan to realize the UTC goal;
2. Issue an updated report containing the newly annexed areas and the new wards within six months of the availability of digital shapefiles for the new ward boundaries; and,
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Glossary

d.b.h.: Diameter at breast height (1.4m or 54 in. above the ground). A standard measure of tree size in forestry and arboriculture.

Exempt Commercial: A land use type recognized by MD Property View®. It is locally defined and includes lands that are zoned commercial and exempt from property taxes. These include federal, state, county, and municipal lands, and certain private tax-exempt lands normally associated with non-profit entities.

Existing UTC: Any piece of land in the city that was covered by tree canopy at the time of satellite data acquisition.

IKONOS: A commercial satellite that collects high-resolution imagery panchromatic (black and white) imagery at a resolution of 1-meter and multispectral (natural color and near infrared [NIR]) imagery at a resolution of 4-meters. Space Imaging, Inc. distributes IKONOS imagery under the product name CARTERRA.

Possible UTC: Any piece of land in the city that is not occupied by a building, existing UTC, a street, or water. Those areas that are deemed possible primarily include grass and non-road/non-building paved surfaces

PROW: Land that falls within the public road right-of-way, derived by identifying all non-parcel lands. This land use type is not recognized by MD Property View®.

Strategic Urban Forests Assessment: A process to extract UTC information from high-resolution remote sensing imagery. A vegetation mask is created from the NIR-to-red, (Band4:Band3) ratio image. A texture image of the resulting ratio image is produced to separate UTC vegetation from non-UTC vegetation pixels (separate trees from other vegetation). The resulting image provides for quantification of existing UTC and non-UTC vegetation.

Urban Tree Canopy: Urban tree canopy (UTC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above.

Urparian: Urparian describes the vegetated areas around roads and sidewalks. The term comes from combining urban and riparian to form a single word. In less urbanized systems, the corridor around streams (the riparian zone) is extremely important for water quality. This area of vegetation captures and processes pollutants before they can make it into surface waters. In urban areas, however, riparian zones are often less effective at removing pollutants. One reason is that urban streams tend to be deeply incised, causing the riparian zone to be disconnected from the stream below. Secondly, the streams in many urban areas have been functionally replaced with storm sewers. In this context, the soil and vegetation around roads and sidewalks is the new riparian zone. By increasing tree canopy in the urparian zone, we can return some of the environmental benefits of riparian areas to urban systems.

Figures

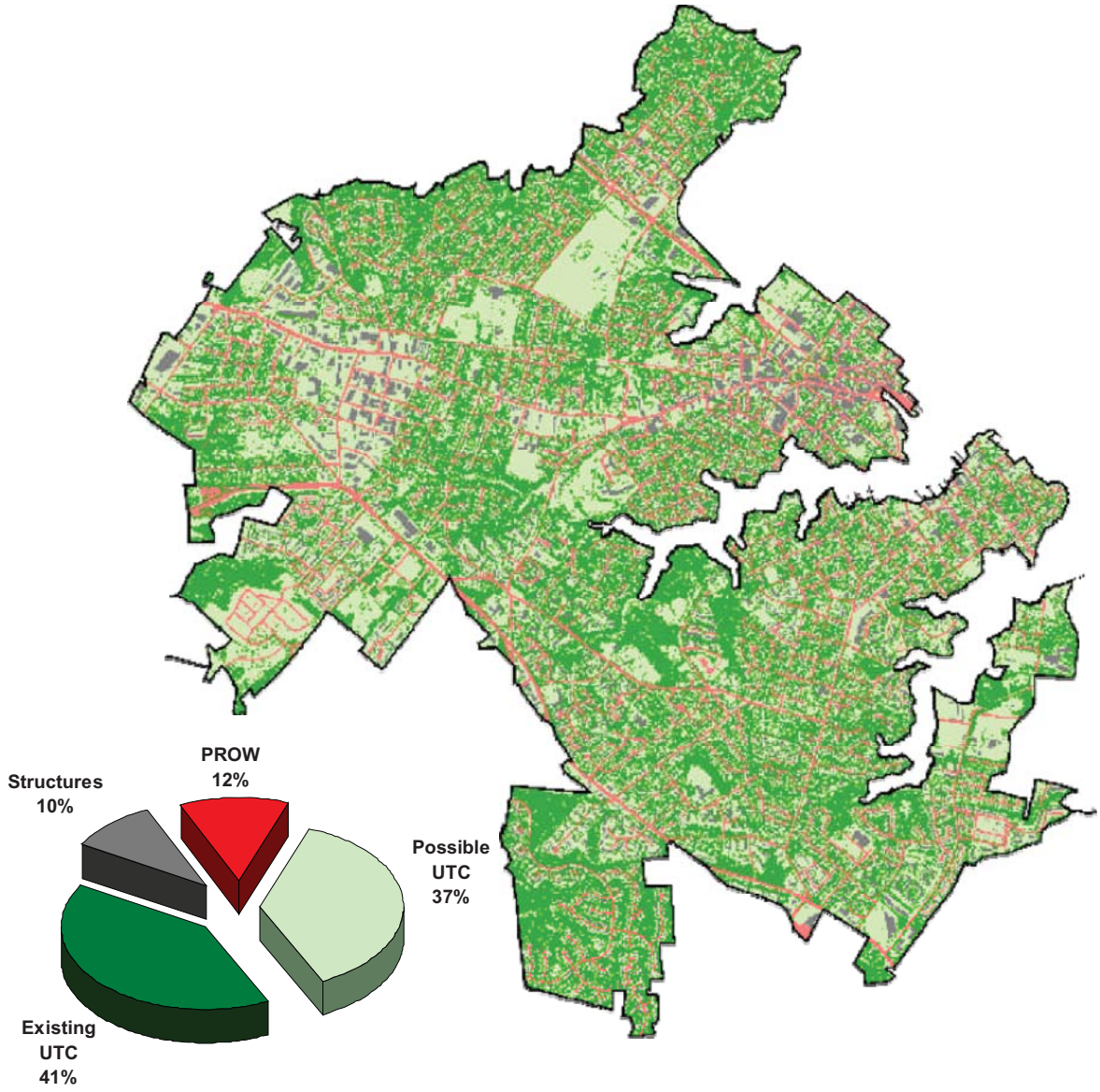


Figure 1 – Current condition from a UTC perspective

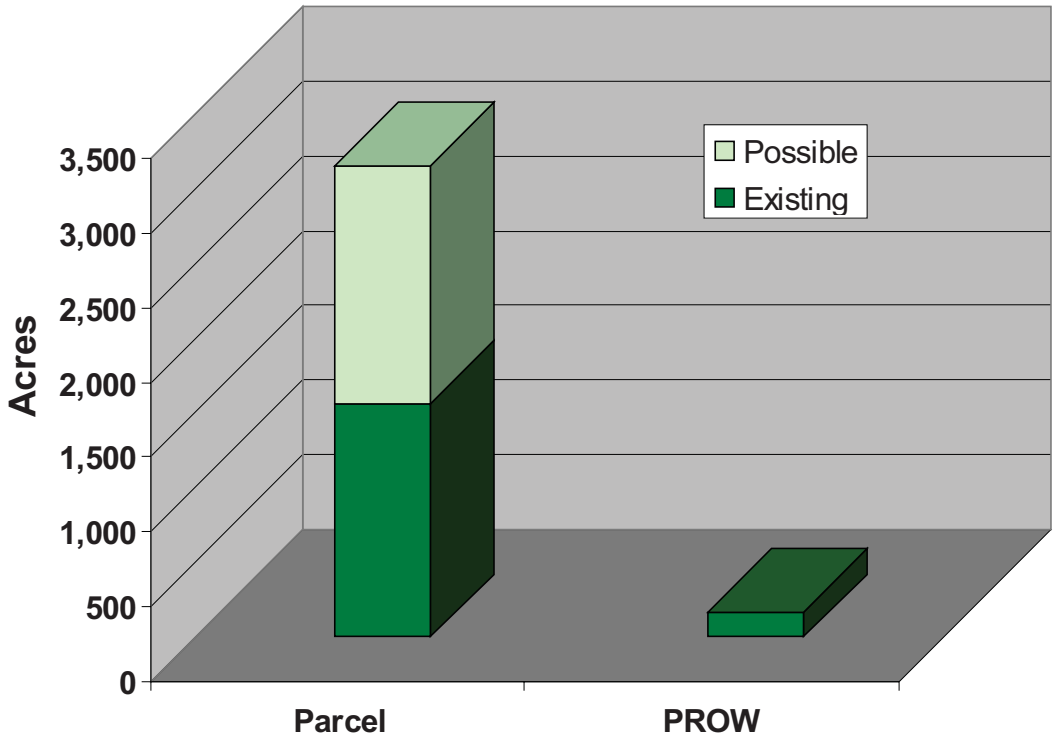


Figure 2 - Existing and possible UTC on parcel lands and PROW

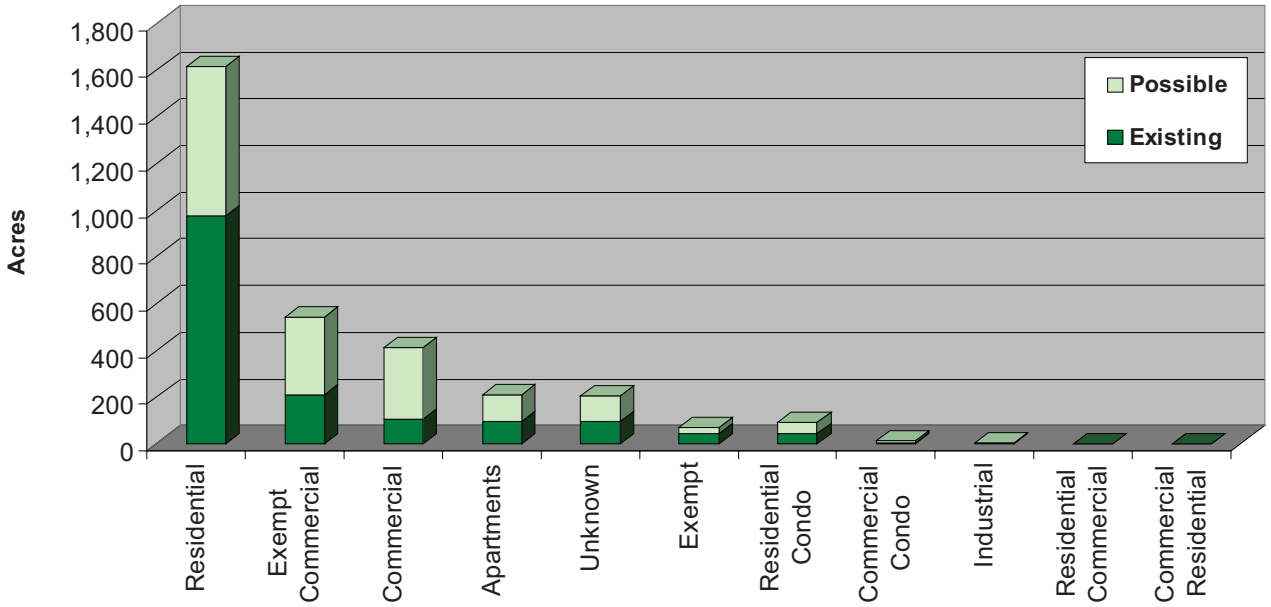


Figure 3 – Existing and possible UTC on parcel lands by land use type

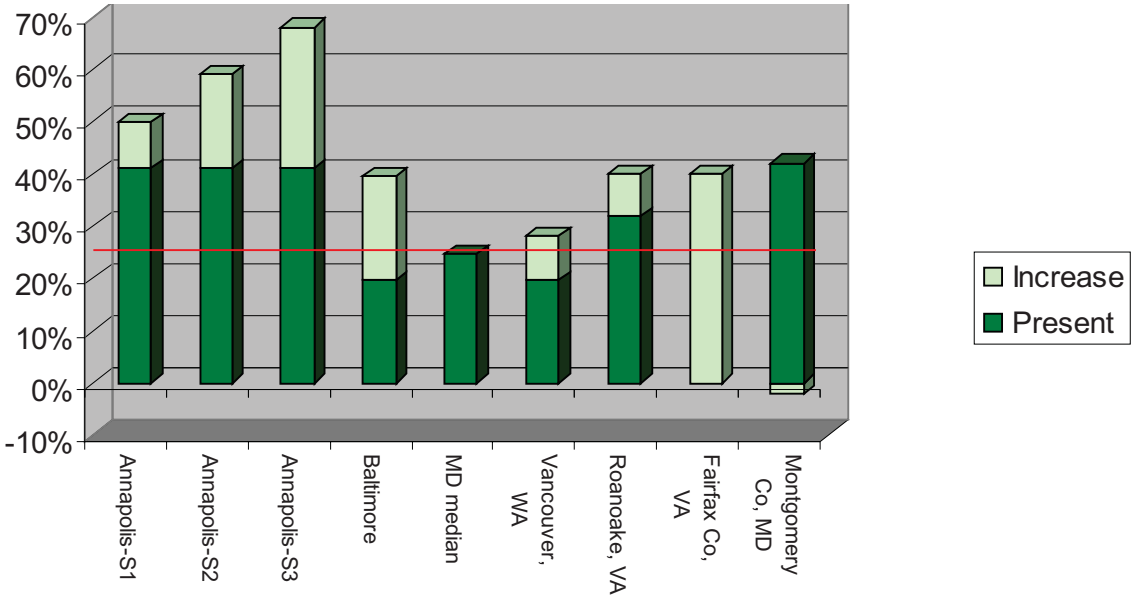
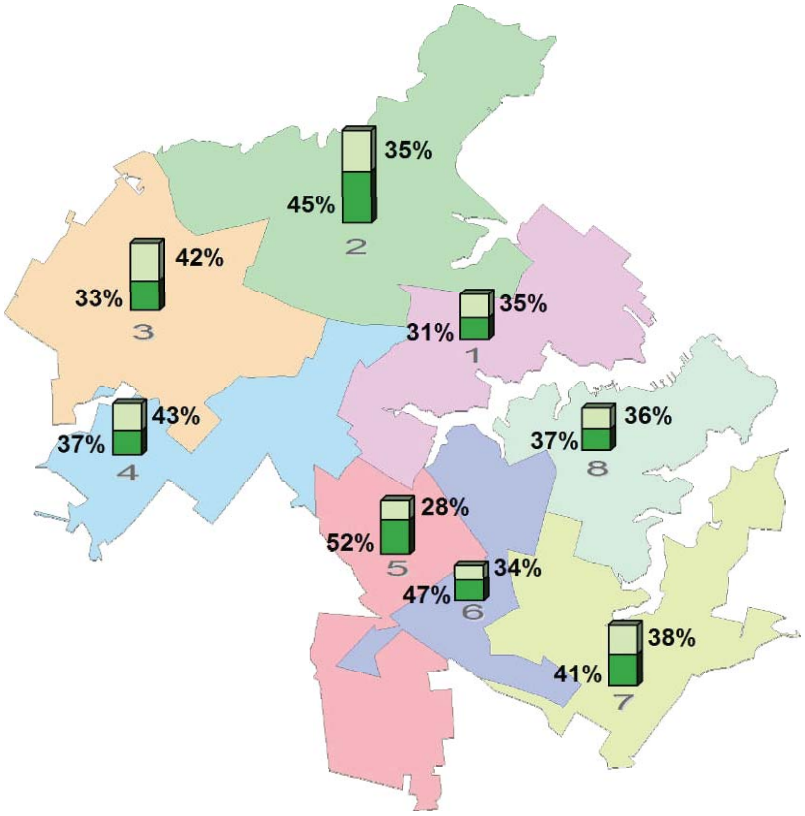
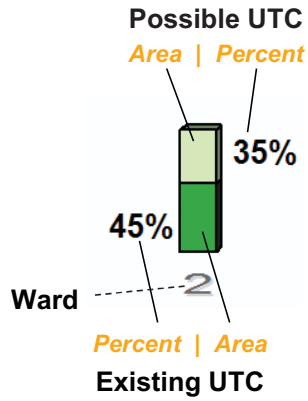


Figure 4 - Comparison of existing and possible UTC among scenarios and jurisdictions





**Area is the total existing/possible for the respective ward*
**Percent is the existing/possible for the respective ward ÷ ward land area*

Figure 5 - Existing and possible UTC by Ward

Tables

Land Area		
Land Type	**Acres**	**Percent of Total Area**
City	4274	
PROW	694	16%
Parcel	3580	84%
Parcel Breakout by Land Use Code		
Unknown	221	5%
Commercial	510	12%
Commercial Condo	13	0%
Commercial Residential	0	0%
Exempt	71	2%
Exempt Commercial	607	14%
Industrial	6	0%
Apartments	239	6%
Residential	1805	42%
Residential Condo	109	3%

Table 1- Land types in acres and as a percentage of the total City area

Existing UTC		
Land Type	**Acres**	**Percent of Total Area**
City	1737	41%
PROW	171	4%
Parcel	1566	37%
Parcel Breakout by Land Use Code		
Unknown	94	2%
Commercial	103	2%
Commercial Condo	3	0%
Commercial Residential	0	0%
Exempt	44	1%
Exempt Commercial	209	5%
Industrial	2	0%
Apartments	96	2%
Residential	974	23%
Residential Condo	41	1%

Table 2 - Existing UTC by land type in acres and as a percentage of the total City land area

Possible UTC		
Land Type	**Acres**	**Percent of Total Area**
City	Unknown	0%
Urparian	Unknown	0%
Parcel	1588	37%
Parcel Breakout by Land Use Code		
Unknown	110	3%
Commercial	305	7%
Commercial Condo	8	0%
Commercial Residential	0	0%
Exempt	26	1%
Exempt Commercial	331	8%
Industrial	3	0%
Apartments	112	3%
Residential	641	15%
Residential Condo	51	1%

Table 3 - Possible UTC by land type in acres and as a percentage of total City land area

	Existing UTC		Possible UTC		Existing + Possible		S1: Realize 25% of possible		
Category	**Acres UTC**	**% Total Land area**	**Acres UTC**	**% Total Land area**	**Acres UTC**	**% Total Land area**	**Acres UTC**	**% Total Land area**	**% UTC Increase**
City	1,737	41%	1,581	37%	3,318	78%	2,132	50%	23%
PROW	171	4%	0	0%	171	4%	171	4%	0%
Parcel	1,566	37%	1,588	37%	3,153	74%	1,962	46%	25%
Unknown	94	2%	110	3%	204	5%	122	3%	29%
C	103	2%	305	7%	409	10%	180	4%	74%
CC	3	0%	8	0%	10	0%	4	0%	76%
CR	0	0%	0	0%	0	0%	0	0%	0%
E	44	1%	26	1%	70	2%	50	1%	15%
EC	209	5%	331	8%	540	13%	292	7%	40%
I	2	0%	3	0%	4	0%	2	0%	46%
M	96	2%	112	3%	209	5%	124	3%	29%
R	974	23%	641	15%	1,615	38%	1,134	27%	16%
RC	0	0%	0	0%	0	0%	0	0%	0%
U	41	1%	51	1%	92	2%	53	1%	32%

Table 4 - Scenario 1: Realization of 25% of possible UTC

	Existing UTC		Possible UTC		Existing + Possible		S2: Realize 50% of possible		
Category	Acres UTC	% Total Land area	Acres UTC	% Total Land area	Acres UTC	% Total Land area	Acres UTC	% Total Land area	% UTC Increase
City	1,737	41%	1,581	37%	3,318	78%	2,528	59%	46%
PROW	171	4%	0	0%	171	4%	171	4%	0%
Parcel	1,566	37%	1,588	37%	3,153	74%	2,359	55%	51%
Unknown	94	2%	110	3%	204	5%	149	3%	58%
C	103	2%	305	7%	409	10%	256	6%	148%
CC	3	0%	8	0%	10	0%	6	0%	151%
CR	0	0%	0	0%	0	0%	0	0%	0%
E	44	1%	26	1%	70	2%	57	1%	30%
EC	209	5%	331	8%	540	13%	375	9%	79%
I	2	0%	3	0%	4	0%	3	0%	91%
M	96	2%	112	3%	209	5%	152	4%	58%
R	974	23%	641	15%	1,615	38%	1,295	30%	33%
RC	0	0%	0	0%	0	0%	0	0%	0%
U	41	1%	51	1%	92	2%	66	2%	63%

Table 5 - Scenario 2: realization of 50% of possible UTC

	Existing UTC		Possible UTC		Existing + Possible		S3: Realize 75% of possible		
Category	Acres UTC	% Total Land area	Acres UTC	% Total Land area	Acres UTC	% Total Land area	Acres UTC	% Total Land area	% UTC Increase
City	1,737	41%	1,581	37%	3,318	78%	2,923	68%	68%
PROW	171	4%	0	0%	171	4%	171	4%	0%
Parcel	1,566	37%	1,588	37%	3,153	74%	2,756	64%	76%
Unknown	94	2%	110	3%	204	5%	177	4%	88%
C	103	2%	305	7%	409	10%	332	8%	222%
CC	3	0%	8	0%	10	0%	8	0%	227%
CR	0	0%	0	0%	0	0%	0	0%	0%
E	44	1%	26	1%	70	2%	63	1%	44%
EC	209	5%	331	8%	540	13%	457	11%	119%
I	2	0%	3	0%	4	0%	4	0%	137%
M	96	2%	112	3%	209	5%	181	4%	87%
R	974	23%	641	15%	1,615	38%	1,455	34%	49%
RC	0	0%	0	0%	0	0%	0	0%	0%
U	41	1%	51	1%	92	2%	79	2%	95%

Table 6 - Scenario 3: realization of 75% of possible UTC

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